



Less rain, more water in ponds, from remote sensing evidence to hydrological processes.

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The Sahel drought, which has started in the 70s is characterized by a paradoxical but apparently general increase of surface runoff. This phenomenon was first diagnosed in cultivated Sahel and it has usually been attributed to land-use change, although possible climate causes were also mentioned. The diagnostic was based on observed increase water table in Western Niger and increase river flows among other observations.

Recently, Gardelle et al. 2010 (Hydrol. Earth Syst. Sci., 14, 309-324) established that in the Gourma region (centered 16 N, 1.5 W), which is mainly an uncultivated pastoral area in Malian Sahel, ponds' surface has dramatically increase between 1954 (peak of the wet period) and 2008 (after 30 mostly dry years). A total increase of +108% was observed for 91 ponds.

In that case, the cause of ponds' surface increase was also attributed to enhanced surface runoff. Indeed, in the Gourma, the ponds are fed by runoff originating on shallow soils (rocky outcrops or hardpans), which occupy 35% of the area. The mechanism first put forward to explain this phenomenon was a change from sheet runoff to concentrated runoff co-occurring with a degradation of vegetation responding to the extreme droughts of 1973 and 1984. As vegetation decay is probably the trigger of the eco-hydrological changes, the concentration of runoff water in gullies further deprives plants of water resources, thud leading to a co-evolution process. Changes from banded vegetation, perpendicular to the slope, to scattered trees growing along gullies parallel to the slope are typical of the co-evolution process.

To further investigate this paradoxical increase of runoff, a close examination of a small watershed, Tin Adjar, already studied in 1956-58 by Dubreuil and co-workers, was performed. The gully network, vegetation cover and soil types were mapped according to aerial photographs taken in 1954, Quickbird high-resolution satellite image in 2007, and several field survey in 2006, 2007 and 2008. The gully network displays a spectacular increase, densification and branching between these two periods, together with a widening of the wadis and drainage of ephemeral shallow ponds. All these elements point toward enhanced runoff taking place during the multi-decadal drought.

As expected, a regression of plant cover was observed, but this study also reveals rapid changes in soil types caused by erosion: larger rocky outcrops, disappearance of loamy-sand soils, sandy soils in the lowest part of the watersheds. Therefore, the hypothesis that vegetation cover and runoff concentration has caused increase runoff and larger ponds had to be complemented with a rapid soil erosion. This third factor reinforces the permanent character of the observed eco-hydrological changes since it would require sand sheets to cover the rocky outcrops or hardpans again to allow vegetation to settle and develop. Therefore, even if rainfall in the recent years seem to recover partially in the Sahel, there is little prospect for a rapid return to the pre-drought conditions on shallow soils.